Teardrop - a rapid reef mosaicing tool for coastal communities

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Abstract. We demonstrate Teardrop – a rapid reef mosaicing tool that can make fast and frequent surveys of shallow reefs at low cost. The hardware component is a hollow, teardrop-shaped wing that holds a waterproof digital camera in video mode while being towed by a boat or a swimmer over reefs. Captured video are parsed into images and stitched using Microsoft Image Composite Editor (ICE), a free panorama stitching software. Using this tool, we have shortened the time to make a composite image of the reef floor from one week to one day. Our aim is to make Teardrop easy to use and to deploy to coastal resource managers, local government units or marine scientists such that they can do the reef surveys themselves. Traditional reef video surveys are costly because of the logistics involved in bringing experts, divers, and their equipment to a site. Using Teardrop mounted with a commercial underwater camera is cheaper to maintain and less difficult to manipulate than using a remotely operated vehicle (ROV). In addition, it can cover a larger area if towed by a banca. Bancas are slender, outriggered boats used by most fishermen in the Philippines. We report Teardrop's performance and our experience in deploying Teardrop to different coastal communities around the Philippines.

Key words: Reef mosaicking, video, Teardrop, coastal communities, image stitching.

Introduction

Coral reef monitoring in an archipelago such as the Philippines is often times costly because of the logistics required to bring people and equipment to a site. Yet it needs to be done repeatedly for proper coastal resource management, and sometimes quickly as in the case of reef damage due to man-made or natural catastrophes such as ship grounding, oil spills, or tsunamis.

Among the field survey methods manta tow is the quickest and easiest to implement. A boat, a trained assessor and a waterproof tally sheet are the only requirements for this survey technique. However, coral cover estimations may greatly vary among assessors and observer bias is a possibility.

Video transect is a field survey method that provides a permanent visual record of the reef. Processing of data is done offline and usually takes time. This technique however requires expensive equipment and several man-hours for post processing.

We propose that to be able to make rapid and frequent surveys of reefs at affordable cost, it is best to outsource reef assessment to coastal communities. This requires that coastal resource stakeholders be provided with equipment and protocols that are easy to use, fabricate, and repair. The system should have the ease of use of manta tow and the recording capability of video transect.

To this end, we developed Teardrop. Teardrop consists of a towable teardrop-shaped, finned hull, an off-the-shelf underwater camera, a GPS logger and freely downloadable stitching software. Attached in its hull is a holder for an underwater camera such as Canon D10 set to capture in video mode.

The common mode of sea transport around the Philippines is a *banca*, this is a slender, outriggered boat made usually of wood and bamboo and used by most subsistence fishermen in the Philippines. Powered by a motor engine, *bancas* are also used to ferry tourists between islands. Inter-island distances in archipelagic Philippines can oftentimes be less than tens of kilometers, thus these small boats are everywhere and can be hired at a cheap rate.

By attaching a GPS logger on the *banca* and towing Teardrop with camera in video mode we create a video transect system that is cheaper, easy to operate, diverless, and most appropriate for our setting.

We have been developing and testing this system since 2010. In 2011 and early 2012 we began deploying this tool to marine scientists and local government units.

This paper reports the development of Teardrop and our experience with promoting the tool among stakeholders. It is hoped that our system can find use in other developing countries with limited resources for coastal surveys.

Material and Methods

Teardrop and Video Capture Protocol

Teardrop is shown in Fig.1. Metal parts include the frame, fins, hooks and camera holder. For the shell, we have tried fiber glass and clear polycarbonate plastic. Overall, the hull costs US$ 45 to assemble. Fig. 2 shows a fiber glass Teardrop with an underwater camera already attached. Video capture relies only on ambient light for illumination. An opaque shell causes shadows on the captured video thus we used a clear shell in later surveys.

Compact underwater cameras that are waterproof up to 10 meters are now commercially available. We used a Canon D10 (around US$ 250) operating in video mode (VGA 640x480 pixel per frame at 30 frames per second). For GPS logging, we used an iGotU GPS Logger (US$ 55).

Figure 1: "Teardrop" is a boat-towable, finned hull for holding a video camera. It is lowered beside a boat by a rope and towed to capture videos of coral reefs along a coast.

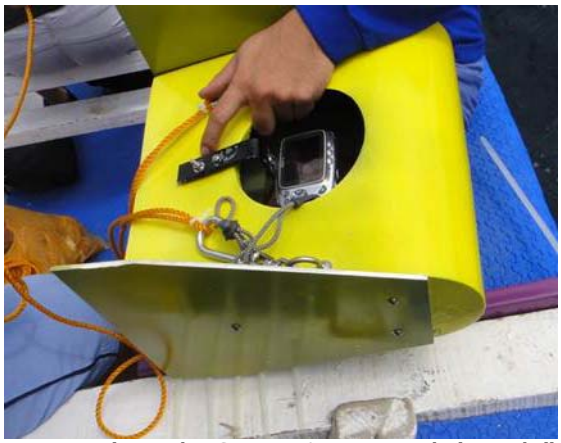

Figure 2: Teardrop with a Canon D10 camera attached to its hull. The Canon D10 is waterproof up to 10 meters.

We limit our captures to corals within a 5-meter depth. Survey times are between 8AM and 4PM when sunlight is sufficient for video capture at this depth. To use Teardrop, tie it to the side or outrigger of the banca, turn on the video mode of the underwater camera, lower it into the water and tow Teardrop around the coast. To avoid motion blur in the video, limit the banca speed to 3 knots or less. With cameras that can capture in HD and at 60 frames per second, the boat may go faster. Fig. 3 shows the steps in Teardrop deployment by boat towing. In the case of shallow corals (1.5m or less) Teardrop can be towed by hand by swimming or wading.

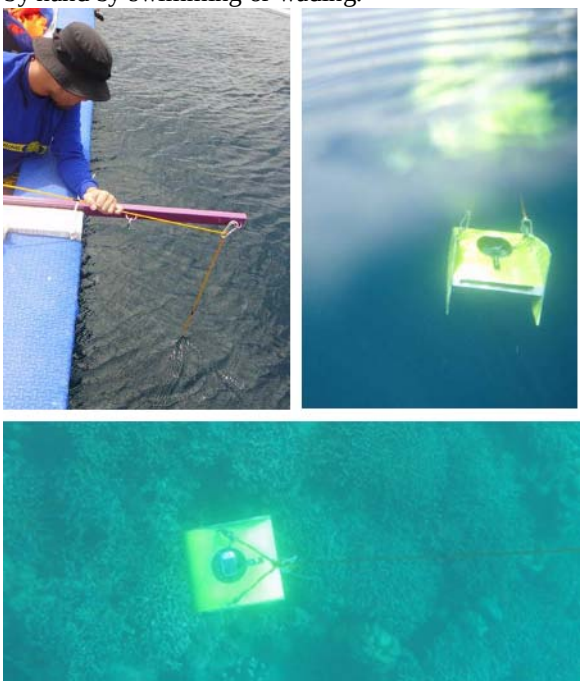

Figure 3: Teardrop is simply lowered at the side of the boat and towed at 3 knots while the attached camera is set to video capture mode. At this speed, video blur is minimized.

The depth at which Teardrop is lowered depends on the topography of the reef and the required resolution. For example, Teardrop can be lowered close enough to the corals if species identification is to be done on the resulting images. If there are tall massive corals along the path of the boat, Teardrop can be tied to a fixed depth above that of the tallest coral or can pulled up to avoid collision.

Image Stitching

Captured video can be parsed into image frames and stitched to form a coral reef mosaic. Previous works include that of (Lirman et al. 2007). We found and tested several image stitching software including bundled software that came with our camera.

Good results were obtained with two freely downloadable software:

- Microsoft ICE

(http://research.microsoft.com/en-us/um/redmond/groups/ivm/ice/)

- Autostitch (Browne, Lowe 2007) (http://www.cs.bath.ac.uk/brown/autostitch/autostitch.html)

When run in Windows 7 Microsoft ICE can take in video inputs. Autostitch will require prior parsing of video into separate frame images. To this end free software such as Avidemux (http://avidemux.berlios.de/) may be used. Both Microsoft ICE and Autostitch may fail if too long a video sequence or too many images are used as inputs. In our experience, frames in a 6-second video sequence will produce good mosaic results with the least distortion. Fig. 4 and 5 show the result of stitching with Microsoft ICE and Autostitch, respectively.

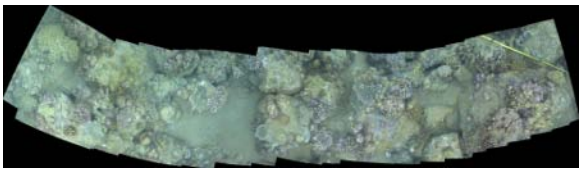

Figure 4: Coral reef video stitching result using Microsoft ICE ™.

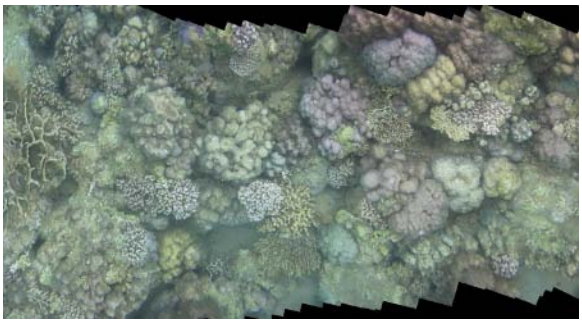

Figure 5: Coral reef video stitching result using Autostitch ™

A stitched image may already be useful for local governments as it can provide a visual record of the reef and its state. For coastal resource managers, image analysis such as coral cover estimation and counting can be done on the stitched images to provide numbers to help assess the status of the reef.

Image mosaicing using the above software is fast. Stitched segments of the coral reef video can be done within the same day as field survey.

Results

In 2011 we began deploying Teardrop to coastal resource stakeholders. Groups which received Teardrop donations were carefully selected. It is important that the receivers will find immediate use for the tool. This is why the first round of recipients are universities with an active marine science institute and local government units with a coastal management team. For each of the recipient groups we conducted a pre-field workshop, a joint-field survey and demonstration, and a post-field workshop during which feedback is collected and Teardrop units are donated.

In 15-18 October 2011 we demonstrated the use of Teardrop to marine scientists from the Institute of Environmental and Marine Science, Silliman University, Dumaguete City. We then let the marine scientist themselves try it out in Apo Island. Shown in Fig. 6 is the GPS track of the boat towing Teardrop around Apo Island on 17 October 2011. Fig. 7 is an example of stitched video which they processed themselves.

Figure 6: GPS track of boat towing Teardrop on 17 October 2011 around Apo Island, Dumaguete City Philippines overlaid on Google Earth.

Figure 7: Stitched image of Apo Island sea floor from video captured and processed by Silliman University marine scientists.

During the post field workshop the marine scientists suggested that we include coral cover estimation among our tools. They also requested a modification for Teardrop such that it can capture corals on a wall structure such as in Bohol Island.

In 19-23 January 2012, two groups in Puerto Princesa City, Palawan received training in the use of Teardrop. These were marine scientists from the Western Philippine University (WPU), and marine biologists and fisheries experts from City Agriculturist's Office (CAO). Joint field work and demonstration were conducted in Honda Bay. Fig.8 shows one of the paths a boat towing Teardrop on 20 January 2012. In Fig. 9 is an example of a stitched video segment the participants took themselves. Both

the WPU and CAO participants each had their own Canon D10's which were used in Teardrop.

During the post-field workshop the participants likewise suggested that we include percentage area as a processed output for the stitched images. Since Palawan has many marine protected areas, they suggested that permission must be obtained from the local governments of these sites in advance since bancas are normally not allowed in marine sanctuaries.

Figure 8: GPS Track of boat towing Teardrop on 20 January 2012 around Honda Bay, Puerto Princesa City Philippines overlaid on Google Earth.

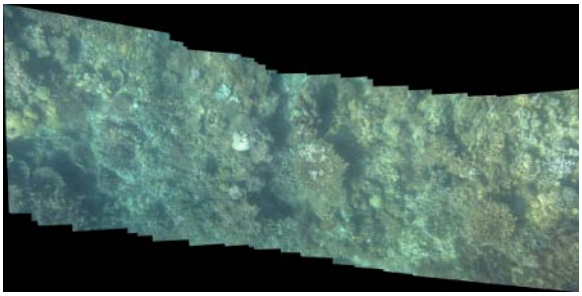

Figure 9: Stitched image from video of Honda Bay coral reef captured by staff from City Agriculturist's Office, Puerto Princesa City, Palawan, Philippines

Discussion

We report the development and deployment of Teardrop a rapid reef video mosaicing system made up of a simple finned hull, a commercial underwater camera, free stitching software and a GPS logger. Overall, the total cost of the system is only US$ 350. This system is designed to be cheap and easy to use for mass deployment to coastal resource stakeholders.

Since January 2012 we have donated 3 Teardrop units to three groups in two locations in the Philippines. The reception to Teardrop was enthusiastic. The end users quickly learned how to manipulate the equipment and run the software. The exchange of ideas was also good with us receiving many more suggestions in improving the tool.

The Teardrop recipients were so chosen because they regularly monitor marine protected sites and sanctuaries in their jurisdiction. For example the office of the city agriculturist in Puerto Princesa usually survey their sanctuaries every 6 months but their survey methods have been limited to manta tow, visual inspection, or still image capture. The marine science institutes in different universities not only monitor sanctuaries but also conduct research on coral reefs. With Teardrop the end-users can now produce permanent visual records of the conditions of their coral reefs for both monitoring and research purposes.

Acknowledgement

This research was done under the "Automated Rapid Reef Assessment System" (ARRAS) program funded by the Department of Science and Technology-Grants In Aid (DOST-GIA).

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